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SUNNYVALE, CALIFORNIA

NOTICE

ABSTRACT

The following annotated bibliography covers publications released during the third quarter of 1962. Citations are arranged alphabetically by author under the broad subject headings of Alloys; Analysis; Applications; Bibliographies; Compounds; Corrosion; Fabrication Techniques; Joining; Mineralogy; Oxides; Powder Metallurgy and Casting; Processing; Properties; and Miscellaneous. Reference to the use of beryllium in fuels, nuclear reactor applications, effects of radiation, and Cu-Be alloys have been omitted.

The resources of Lockheed Missiles and Space Company Technical Information Center were utilized in the preparation of this bibliography.

Search Completed December 1962

BERYLLIUM

ALLOYS

1. ALLOYS OF BERYLLIUM. Italian Patent No. 353882 and Addendum No. 357876. 1937. 56p. (In Italian) (French trans. CEA-tr-X-259).

A study is made of the mechanical and physical properties of alloys of the form X-(1.3 to 2.6%) Be-Y, where X is a metal chemically and crystallographically similar to Cu, Ni, Fe, or Al, and Y is a metal chemically and crystallographically similar to V, Mo, W, Ta, U, Ti, Zr, or Cr. The effects of quenching and tempering operations on these alloys are also examined. Data are given as examples for the alloys Cu-Be-V, Ni-Be-Mo, Cu-Be-V-(3 to 4%) Fe, Ni-Be, and Cu-Be. The alloys are found to possess high rupture strengths, high electric conductivity, high tensile strengths, and hardness.

2. Gilliland, R. G. *et al.* ZIRCONIUM-TITANIUM-BERYLLIUM BRAZING ALLOY. U. S. Patent No. 3,038,249. 12 Jun 1962.

A new and improved ternary alloy is described which is of particular utility in braze-bonding parts made of a refractory metal selected from Group IV, V, and VI of the periodic table and alloys containing said metal as a predominating alloying ingredient. The brazing alloy contains by weight, 40 to 50 per cent zirconium, 40 to 50 per cent titanium, and the balance beryllium in amounts ranging from 1 to 20 per cent, said alloy having a melting point in the range 950 to 1400°C.

3. Jordan, C. B.
INVESTIGATION OF THE EFFECT OF ULTRA-RAPID QUENCHING ON METALLIC SYSTEMS, INCLUDING BERYLLIUM ALLOYS. Electro-Optical Systems, Inc., Pasadena, Calif. Final report covering work conducted from 1 Feb 1961 to 31 Dec 1961. Jun 1962. 34p. [Contract AF33(616)-8011] (ASD-TDR-62-181).

The effect of ultrarapid quenching on eight binary alloy systems, namely, Be-H, Be-O, Be-Al, Be-Si, Be-Sc, Be-Ni, Be-Cu, and Be-Zn, has been investigated. In four of the systems, namely, Be-H, Be-O, Be-Sc, and Be-Zn, attempts to carry out the necessary experiments were unsuccessful because of difficulties as to material or technique which could not be overcome within the scope of the contract. In the other four systems, the best experimental results obtainable indicate that no significant change of structure is produced by rapid quenching.

4. Smith, M. J., R. J. Knight and C. W. Spencer
Properties of Be_2Te_3-Sb_2Te_3 alloys. JOURNAL OF APPLIED PHYSICS v.33, no.7, p.2186-2190, Jul 1962.

Alloys are prepared by mixing above the melting points, cooling and quenching. Measurements are made of the phase diagram, lattice parameters, electrical resistivity and thermal energy gap as a function of temperature and composition.

ANALYSIS

5. Dibbs, H. P.
DETERMINATION OF BERYLLIUM BY GAMMA-RAY ACTIVATION. Canada. Dept. of Mines and Technical Surveys. Mines Branch. Mar 1962. 17p.

An apparatus is described for the quantitative analysis of the beryllium content of powdered samples down to approximately 50 ppm of beryllium. The analytical technique is based upon the photoneutron reaction $Be^9(\gamma, n)Be^8$ and employs antimony-124 as the gamma source. A description is given also of a second apparatus for the qualitative screening of rock samples for beryllium content.

6. Ercko, V. F.
Spectral analysis of magnesium-beryllium alloys.
UKRAINSKII FIZYCHNYI ZHURNAL v.6, p.837–842,
1961. (In Russian)

The methods of spectral analysis of magnesium-beryllium alloys are considered. Beryllium (basic addition), aluminium, zirconium, and calcium were alloying additions. Copper, iron, and nickel were determined as noxious impurities. The determination of the impurities was carried out both by method of solution of a sample and by direct analysis of metal specimens. The determined concentration range was for beryllium 0.003 to 10%; for the other impurities 0.02–0.5%. A spectrophotometric method is proposed for determining beryllium in magnesium alloys. Sulfosalicylic acid was used as a complex former. The influence of magnesium was excluded by the addition of trilon B. The optical density was measured at $\lambda = 317\ m\mu$. The determined concentration range is equal to 10^{-2} to 10%. The method of sodium and potassium determination in magnesium alloys by the method of flame photometry with subsequent photoelectrical registering of the spectrum was carried out.

7. Lifshitz, E. V., et al.
Spectrochemical analysis of some pure metals.
UKRAINSKII FIZYCHNYI ZHURNAL v.6, p.846–850,
1961. (In Russian)

Some methods of spectrochemical analysis of pure metals are considered. Manganese, chromium, beryllium, nickel, cobalt, molybdenum, zinc, iron, zirconium, and silicon were analyzed for the contents of from 7 to 20 impurities. The impurity concentrations varied from 10^{-1} to 10^{-4}%. The accuracy of the determination was 10 to 20%. The following methods were used to increase the sensitivity; fractionalional evaporation in the direct current arc, globule arc, enrichment on evaporational installation, and chemical methods of concentration of impurities.

8. McVay, T. N., et al.
Beryllium chemistry studies. In REACTOR CHEMISTRY DIVISION PROGRESS REPORT FOR PERIOD ENDING 31 JANUARY 1962. Oak Ridge National Laboratory, Tenn. Report ORNL-3262.
11 May 1962. p. 153–156. (Contract W-7405-Eng-26).

Measurements of the refractive indices of irradiated BeO specimens, made before and after thermal annealing, demonstrated that this technique affords a rapid method of measuring the extent of radiation damage to BeO. Attempts were made to produce

a stabilized cubic form of BeO by doping with small amounts of other oxides. No evidence of the formation or stabilization of a cubic BeO phase was observed. A solvent-extraction process for making high-purity BeO was developed, and a small-scale production operation was demonstrated. About 1280 g of BeO was prepared. Spectrographic analyses of this material showed that impurity concentrations were reduced to exceedingly low values. Several batches of this high-purity BeO have found use in preparation of spectrographic standard mixtures. Reports that the tensile strength of beryllia increases markedly as the purity and the crystal perfection are improved suggest that ultrapure BeO might display greater resistance to radiation damage. A spectrographic analysis method was developed for the simultaneous determination of beryllium acetylacetonate and acetylacetone in organic solutions which occur in the solvent-extraction Be purification process. It is based on the ultraviolet absorption peaks of the two components (294 to 272 mμ respectively), which are sufficiently separated that measured sample absorbancies at two wavelengths (260 and 301.5 mμ) can be used in simultaneous equations to obtain the concentration of each component, usually within ±5%.

9. Malinowski, J. and D. Dancewicz
Indirect methods in flame analysis: Indirect flame photometric estimation of beryllium in beryllium bronzes. REVUE UNIVERSELLE DES MINES v. 15, p. 405–407, 1959. (In French)

The suppression of the Sr flame by Be was used to estimate Be in a Be-bronze. A solution of the bronze containing EDTA is made alkaline by adding NH_4OH which precipitates the $Be(OH)_2$. The precipitate is filtered off and dissolved in HCl. A solution of 300 mg/1 Sr (as chloride) is sprayed into the flame photometer which is adjusted to give a full scale reading from the flame. The analysis is completed by adding the Be solution and observing the reduced Sr reading.

10. Richards, R. G.
THE DETERMINATION OF SULPHUR IN BERYLLIUM OXIDE. United Kingdom Atomic Energy Authority. Research Group. Chemistry Division, Chatham Outstation, Kent, England. Report AERE-AM-86. Dec 1961. 9p.

The sample is dissolved in a titanium-phosphoric acid reagent, which reduced sulfate to sulfide. The H_2S thus formed is swept away in a current of N_2 into a zinc acetate solution. By reaction with p-phenylene-diamine and ferric chloride the

sulfide is converted to Lauth's violet, which is determined absorptiometrically. The method is suitable for sulfate concentrations of 20 to 400 ppm, and the error should not exceed ± 10%.

11. Sands, D. E., *et al.*
Crystal structure of rhenium docosa beryllium.
ACTA CRYSTALLOGRAPHICA v. 15, no. 9,
p. 832-834, 1962.

$ReBe_{22}$ is face-centered cubic with a = 11·561 Å; there are eight formula units per unit cell and the space group is Fd3m. Each Re atom has 16 Be neighbors at 2·50 2·53 Å. There are 4 types of Be atoms: Be_1 has 2 Re neighbors at 2·50 Å and 12 Be neighbors at 2·46 Å; Be_2 and Be_3 each have 12 Be neighbors at 2·05 to 2·29 Å; Be_4 has 1 Re neighbor at 2·53 Å and 11 Be neighbors at 2·13 to 2·46 Å.

12. United Kingdom Atomic Energy Authority.
Production Group, Springfields, Lancashire,
England. ANALYTICAL METHOD FOR THE
DETERMINATION OF BERYLLIUM, TITANIUM
AND MANGANESE IN BERYL ORE. PG-Report-
266. 1962. 11p.

The analytical method involves fusing the sample with potassium hydrogen fluoride which is then sulfated. The melt is dissolved in dilute HCl. Beryllium is determined in the solution gravimetrically as pyrophosphate, titanium absorptionmetrically with H_2O_2 and manganese volumetrically after oxidation to permanganate.

APPLICATIONS

13. Beryllium extrusions to lower spacecraft weight.
SPACE/AERONAUTICS v. 37, no. 4, p. 169, Apr 1962.

A process for extruding U-shaped beryllium channels 0.006 inch thick and 39 feet long is claimed as a breakthrough that may aid in developing larger, lighter spacecraft. The technique was developed jointly by Northrop Corporation, Norair Division, Hawthorne, California, and Nuclear Metals, Inc., Concord, Massachusetts.

14. Hoffman, G. A.
THE POTENTIAL OF BERYLLIUM IN SUPERSONIC COMMERCIAL AIRCRAFT.
Rand Corp., Santa Monica, Calif. Memo. no. RM-3094-PR. May 1962. 21p. [Contract AF 49(638)700, Proj. RAND] ASTIA AD-275 519.

A structural comparison is made of Be with the best alloys of Al, Ti, and steel for a variety of applications in supersonic transports. Such applications include components whose design is governed by tension criteria, by compression in stiffened and sandwich panels, and in unstiffened plates, and by notched behavior, all over the temperature range to be encountered in future aircraft. It is inferred that a Be structural part might weigh from 1/4 to 1/2 less than the equal-function part made of more conventional metals. Calculations of the economics of Be usage in aircraft follow, consisting of several derivations of the worth-in-use of the weight reduction in commercial transports obtained by substituting a lighter-weight, but costlier, Be component. It is concluded that Be would offer many economic and weight-reducing advantages for transports.

15. Hotchkiss, E. B.
Beryllium. MINING CONGRESS JOURNAL v.48, no.2, p.105–107, Feb 1962.

Research on the mining, extraction and production of Be, beryllides and barylite. Review of potential applications and fabrication methods.

16. Krusos, J. N.
SHEET BERYLLIUM COMPOSITE STRUCTURES.
Aeronca Mfg. Corp., Middletown, Ohio. Interim technical documentary progress report, 1 Jan – 31 Mar 1962. 31 Mar 1962. 38Sp. [Contract AF 33(657)-7151, Proj. 7-845] (ASD TR 7-845, v.2) ASTIA AD-276 815.

The program was redirected to meet super-orbital mission loads as the design objective. The design surface temperature of the forebody structure during re-entry is retained at 3400° F, and an ablative coating is contemplated to resist extreme heat

rates which occur briefly during the super-orbital re-entry phase. Materials A-286 and Inconel X honeycomb, A-286, Inconel X and Be facing sheets. Development work is well underway on forming and brazing techniques particularly of Be. Material selections for the heat shield are not final but at present a refinement of the basic 40 lb/cu ft alumina foam is most promising. Composite panels were subjected to the ram-jet exhaust environment.

17. Palmer, J. E.
Chemical saw; cutting small samples from beryllium single crystals. METALLURGIA v.64, no.386, p.303-304, Dec 1961.

The author describes equipment for cutting small samples from beryllium single crystals. A tungsten were cathode, wetted by a phosphoric/sulphuric acid electrolyte is drawn backwards and forwards across the anode – the beryllium crystal.

18. Rhoten, M. L., J. P. Mitchell, and R. C. McMaster
NONDESTRUCTIVE SYSTEM FOR INSPECTION OF FIBER GLASS-REINFORCED PLASTIC MISSILE CASES. Ohio State University Research Foundation, Columbus. Technical report no. 2, 20 Jan 1962. 12p. (Contract DA-33-019-ORD-3670) (WAL TR 142.5/2-1).

The purpose of this research is to develop a television x-ray imaging system for the nondestructive inspection of fiber glass-reinforced plastic missile case walls and materials. Beryllium-window tubes were evaluated by measuring the target signal produced by varying quantities of x-radiation at different kilo-voltages. A sketch of the instrumentation used for making these measurements is presented. For the comparison with previous tube data, and to determine variations in response to various radiation wavelengths, evaluation tests were made using the 220-kvp glass-window x-ray tube and a 150-kvp beryllium-window x-ray tube. Gamma curves for the different vidicon tubes showing the response to the different radiation wavelengths are presented.

19. Stockett, S. J.
Metals and processing methods used in the Mercury spacecraft. METAL PROGRESS v. 81, p. 68 – 74, Jun 1962.

The basic structure for the Mercury spacecraft is a Ti alloy frame which supports a pressure vessel made by seam welding contoured sections of Ti sheet together. Between the heat resistant outer skin – composed of beaded Rene 41 shingles – and the pressurized cabin is a blanket of highly efficient, lightweight thermal insulation.

BIBLIOGRAPHIES

20. Goldmann, J. B., comp.
BERYLLIUM: A SURVEY OF THE LITERATURE, AUGUST–DECEMBER 1961. SUPPLEMENT II. Lockheed Missiles and Space Co., Sunnyvale, Calif. SB-61-35(Supl. II). Mar 1962. 137p. (Contract NORD-17017).

A bibliography of publications is presented under the subject headings of alloys, analysis, applications, compounds, corrosion, fabrication, joining, powder metallurgy, and properties. Several sources were searched. (309 references).

COMPOUNDS

21. Addison, C. C. and A. Walker
Basic beryllium nitrate. CHEMICAL SOCIETY. PROCEEDINGS p. 242. Jul 1961.

Beryllium chloride undergoes solvolysis in ethyl acetate-dinitrogen tetroxide mixtures to give pale-straw crystals of the addition compound $Be(NO_3)_2 \cdot 2N_2O_4$. When heated in a vacuum, this decomposes in two stages. Dinitrogen tetroxide is evolved rapidly above 500, leaving anhydrous beryllium nitrate, $Be(NO_3)_2$, as a white powder which has no detectable volality. At about 125°, sudden decomposition occurs to give dinitrogen tetroxide and a volatile beryllium compound which separates from the gas phase as colorless crystals. Analyses correspond with the formula $Be_4O(NO_3)_6$

(found: Be, 8.5, N, 19.5. Calculated for $Be_4O(NO_3)_6$: Be 8.5; N 19.8%). The structure, which the basic nitrate is believed to possess, is given. The basic nitrate is analogous with basic beryllium acetate and properties of the two compounds are compared.

22. Aitken, E. A. and J. P. Smith
Oxidation of beryllium intermetallic compounds in moist atmospheres. JOURNAL OF NUCLEAR MATERIAL v.6, no.1, p.119, 1962

Beryllium intermetallic compounds, as well as beryllium metal, react with moisture-containing atmospheres at a relatively high rate in the 1000-1800° F (538-982° C) temperature range.

23. Bhattacharya, A. K. and G. S. Rao
Physico-chemical study of the complex formation of beryllium ions with organic ligands, with malonic acid and its derivatives. ZEITSCHRIFT FUER PHYSIKALISCHE CHEMIE (Leipzig) v.219, no.1/2, p.11-16, 1962. (In English)

Beryllium sulfate was found to form 1:1 complexes with malonic acid, sodium malonate, and diethyl malonate. The complex formation was studied by the electrical conductance date, potentiometric data, and spectrophotometric data in the ultraviolet region with the help of Job's continuous variation method. The values of the dissociation constants thus obtained are 9.55×10^{-4} for malonic acid, 9.24×10^{-4} for sodium malonate, and 9.81×10^{-4} for diethyl malonate at 28° C. A precise structure was attributed to the complex formed and justified both from theoretical considerations and from practical data. As can be seen from a comparison of the values of the dissociation constants, the complex with sodium malonate is slightly more stable than the complex formed with malonic acid and the complex formed with the ethyl substituted malonic acid is slightly less stable than that formed with malonic acid, presumably due to the weakening of the electron donating properties of the acid.

24. Booker, J., R. M. Paine, and A. J. Stonehouse
INVESTIGATION OF INTERMETALLIC COMPOUNDS FOR VERY HIGH TEMPERATURE APPLICATIONS. Brush Beryllium Co., Cleveland, Ohio. Report no. WADD-TR-60-889. Dec 1960. 143p. [Contract AF33(616)-6540] ASTIA AD-265 625.

Intermetallic beryllides from the systems Ta – Be, W – Be, and Hf – Be along with the disilicides of W, Ta, and Mo, were screened for compounds capable of serving as structural materials at temperatures above 2500° F. The compounds studied were $TaBe_{12}$, Ta_2Be_{17}, Hf_2Be_{21}, $MoSi_2$, $TaSi_2$, and WSi_2. An investigation of the rates of oxidation of intermetallic beryllides were initiated. The oxidation of $TaBe_{12}$, Hf_2Be_{21}, $ZrBe_{13}$, and Ta_2Be_{17} at 2300 to 2750° F was found to obey an exponential rate law which was cubic or a higher power rate law. In most cases, the cubic rate law applied. The products of the oxidation of $ZrBe_{13}$ at 2500° F were identified as Zr_2Be_{17} and BeO. Tentative activation energies for a cubic rate process were calculated for $TaBe_{12}$ and Hf_2Be_{21}.

25. Bruin, H. J. de., D. Kairaitis and L. Szego
Solvent extration of mono(salicylato) beryllium, and the pH titration of the system beryllium-salicylic acid. AUSTRALIAN JOURNAL OF CHEMISTRY v. 15, no. 2, p. 218–227, 1962.

It has been shown that a salicylatoberyllium complex can be extracted from aqueous solutions by aliphatic alcohols. The distribution ratio is a symmetrical function of the logarithm of the free ligand concentration and passes through a maximum value; the stability constants of the mono- and bis(salicylato)beryllium complexes have been determined from the data for points of equal extraction. The values obtained in this war are $\beta_1 = 4 \cdot 1 \times 10^{12}$ and $\beta_2 = 4 \cdot 3 \times 10^{22}$, in an ionic strength of 0·15. They agree fairly well with those obtained by pH·titration procedures, which are $\beta_1 = 6 \cdot 1 \times 10^{12}$ and $\beta_2 = 7 \times 10^{22}$.

26. Coates, G. E. and S. I. E. Green
Beryllium complexes with bipyridyl and other chelate donor groups. Evidence for the bipyridyl anion as donor. CHEMICAL SOCIETY JOURNAL n.9, p. 3340–3347, 1962.

Dimethylberyllium forms monomeric 1:1 complexes with the chelating donors 1, 2-dimethoxyethane and NNN'N'-tetramethylethylenediamine. NNN'-Trimethylethylenediamine yields a dimer ($Me_2N \cdot CH_2 \cdot CH_2$ NMe BeMe$)_2$, and the dimethylethylenediamines give polymers. Dialkyl and diaryl derivatives of beryllium form colored 2,2'-bipyridly complexes [R_2 bipy Be] , whose colors deepen as the group R becomes less electronegative. The color is ascribed to a charge-transfer transion from a Be-C bond to the bipyridly group. Organic derivatives of some other Group II metals give colored bipyridyl complexes, e.g., [Me_2bipy Zn] . Reaction between Li_2 bipy and [Cl_2 bipy Be] or between Li bipy and beryllium chloride gives a deep green paramagnetic complex [$bipy_2$ Be] , which is regarded as a complex between two bipyridal monoanions and the beryllium cation. The complex Li [$bipy_2$ Be] , deep violet blue in either solution, was also prepared. Benzene-soluble sulphide complexes of beryllium chloride, [$Cl_2(Me_2S)_2Be$] , [$Cl(Me_2S)BeCl_2Be(Me_2S)Cl$] , and [$Cl_2(MeSC_2H_4SMe)Be$] , are also described.

27. Harris, L. A., R. A. Potter, and H. L. Yakel
Preliminary observations of mixed oxide compounds containing BeO. ACTA CRYSTALLOGRAPHICA v. 15, p. 615–616, Jun 1962. (In English)

In the course of a survey of phase formation in mixed oxide systems containing BeO, the compounds 2 CaO · 3 BeO, 2 SrO · 3 BeO, and Y_2O_3 · 2 BeO were synthesized and studied by optical and single-crystal x-ray diffraction methods. Results were reported previously for the calcium and yttrium compounds.

28. Kendall, E. G. and J. D. McClelland
MATERIALS AND STRUCTURES. BERYLLIUM-CONTAINING MATERIALS PROGRAM. Aerospace Corp., El Segundo, Calif. Semiannual technical report, 1 Jul– 31 Dec 1961. Report no. TDR-930(2240-66)TR-1. 3 Mar 1962. 11p. [Contract AF 04(647)930] (DCAS TDR 62-62) ASTIA AD-276 175.

Beryllium and its compounds are being studied to determine the degree to which they will be useful for future missile and space systems. To date, research has concentrated on optical properties of beryllia and the welding of beryllium to itself and other ceramics. The beryllide research studies were surveyed and a research program is underway. A facility has been designed for the handling of Be compounds and other toxic materials.

29. Kripyakevich, P. I. and E. I. Gladyshevskii
Structure of the compounds $CrBe_{12}$, VBe_{12}, and $NbBe_{12}$. AKADEMIIA NAUK SSSR. DOKLADY v. 104, p. 82–84, 1955. (English trans. DC-58-11-114. n.d. 10p.)

A series of intermetallic compounds of Cr, Nb, and V with Be were prepared. Their x-ray diffraction powder patterns indicated compositions identical with respect to each other and sharply differentiated from the x-ray patterns of Be and the XBe-type compounds. It was hypothesized that the compounds are of the type XBe_{12}. The number of atoms in the unit cell and the observed intensities of the lines agreed with this hypothesis. The constants of the elementary cell of $CrBe_{12}$, VBe_{12}, and $NbBe_{12}$ are given along with calculations based on interatomic distances.

30. Mannas, D. A. and J. P. Smith
Beryllium intermetallic compounds – their preparation and fabrication. JOURNAL OF METALS v. 14, no. 8, p. 575–578, Aug 1962.

Investigation aimed at determining effect of impurities and methods of fabrication on properties of beryllides, primarily $ZrBe_{13}$ and $CbBe_{12}$; improvements in vacuum-hot-pressing process increased reproducible yield of satisfactory billets; small cast shapes were produced by arc-melting and casting techniques and feasibility of extruding $ZrBe_{13}$ by coextrusion techniques was established.

31. Mrose, M. E. and D. E. Appleman
Crystal structures and crystal chemistry of vayrynenite, (manganese, iron) beryllium (phosphate) (hydroxide) and euclase, aluminum beryllium (silicate) (hydroxide). ZEITSCHRIFT FUER KRISTALLOGRAPHIE v. 117, no. 1, p. 16–36, 1962. (In English)

Determination and refinement of the crystal structures of vayrynenite and euclase show that these minerals have related, but not identical, structures. Vayrynenite contains chains of $BeO_2(OH)_2$ and PO_4 tetrahedra linked by Mn-O and hydrogen bonds; euclase contains chains of $BeO_3(OH)$ and SiO_4 tetrahedra linked by Al-O bonds. The differences between the two structures are due principally to the difference in electrostatic charge distribution between a structure containing Mn and P and a structure containing Al and Si.

32. Rabenau, A. and P. Eckerlin
Compounds in the system Be_3N_2-Si_3N_4. In SPECIAL CERAMICS. New York, Academic Press, 1960. p. 136–143.

Preparation of the specimens requires a special technique which is described and which has a wide range of application to other investigations. The sytem was investigated between 1600 and 2000° C. There exists a new hexagonal modification of Be_3N_2 which dissolves up to 7 mol % Si_3N_4. Further compounds in the system are Be_4SiN_4 and the wurtzite type type compound $BeSiN_4$.

33. Thompson, C. J., G. C. Sinke and D. R. Stull
Heat of formation of beryllium chloride. JOURNAL OF CHEMICAL AND ENGINEERING DATA v.7, p. 380–381, 1962.

The heats of formation were determined in a rotating bomb calorimeter by dissolving Be in 6.0N HCl. The heat of formation of solid $BeCl_2$ at 298° is -118.25 kcal/mole, in excellent agreement with the literature value determined by direct reaction of Be and Cl.

34. Vuillard, G. and J. C. Rosso
Crystallization of aqueous solutions of beryllium nitrate. ACADEMIE DES SCIENCES. COMPTES RENDUS v.255, no.3, p.521–523, 1962. (In French).

A technique of low temperature thermal treatment has allowed to be placed in evidence two new hydrates in the beryllium water-nitrate system. $Be(NO_3)_2$, $7H_2O$ is transformed at -33.3° C and $Be(NO_3)_2$, 6H O decomposes at -14.5° C. The eutectic frozen-heptahydrate is found at -53.9° C for the composition 38.8%.

35. Zapf, C. F.
FRICTION AND WEAR OF METALLIDED SURFACES. General Electric Co. Aircraft Nuclear Propulsion Dept., Cincinnati, Ohio. Report DC-60-1-146. 19 Jan 1960. 18p. [Contract AT(11-1)-171]

Results of friction and wear tests are presented showing the beneficial effects of boriding on the surfaces of Inconel X and Hastelloy X. Beryllided surfaces of these same alloys failed to stand up under the 6000 psi bearing stresses which were imposed during these tests at temperatures to 1200° F. These tests were of short duration since the data were collected in approximately five hours. During this time friction readings were taken at predetermined points as the specimen temperature was raised to 1200° F and then cooled to 150° F.

CORROSION

36. Aitken, E. A. and J. P. Smith
Oxidation of beryllium intermetallic compounds in moist atmospheres. JOURNAL OF NUCLEAR MATERIALS v.6, no.1, p.119, 1962.

Beryllium intermetallic compounds, as well as beryllium metal, react with moisture-containing atmospheres at a relatively high rate in the 1000-1800° F (538-982° C) temperature range.

37. Cook, N. C.
CORROSION RESISTANT COATING.
U. S. Patent No. 3,024,175. 6 Mar 1962.

A method is given for depositing a uniform, adherent, corrosion-resistant beryllide coating on a metal. The method comprises immersing the metal and Be in a fused bath of BF_3 and 10 to 67 mole % of an alkali metal fluoride and making an electrical connection between the metal and Be outside the bath to deposit Be on the metal. The metals which may be beryllided in this way are those having atomic numbers of 21-29, 39-47, 57-79, and 89-98, and alloys having these metals as major constituents. Several examples of the method are given.

38. Draycott, A., *et al.*
STUDY OF THE VARIABLES AFFECTING THE CORROSION OF BERYLLIUM IN CARBON DIOXIDE. Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales. Report AAEC/E-83. Dec 1961. 34p.

The effects of the following variables on the corrosion of Be by CO_2 were studied: surface preparation of the specimen; temperature (100 to 725° C); pressure (0 to 280 psig); velocity; and impurity content of the gas. The results were statistically analyzed and kinetic data obtained. In all cases specimens with etched surfaces yielded approximately 25 to 30 percent greater weight gains than specimens with ground or polished surfaces. On extruded material no "breakaway" oxidation was encountered below 650° C in commercially dry gas (<20 ppm moisture). The rate of attack as to some extent ~~affected by~~ the pressure of the gas. A basic study of the chemistry of the reaction was made, as well as a detailed investigation into the variation caused by differences in the composition and fabrication of the metal. Extruded material made from beryllium powder, oxidized in dry oxygen for a short time had greatly enhanced oxidation resistance when exposed to carbon dioxide. Some of the material exposed to wet carbon dioxide at 700° C and atmospheric pressure did not exhibit "breakaway" oxidation. The weight gains after 1000 hours exposure under these conditions were never greater than 0.5 mg/cm^2. Some comparisons were made between the reaction rates of beryllium with oxygen and carbon dioxide. In certain circumstances dry oxygen gave breakaway oxidation whereas carbon dioxide did not.

39. Jepson, W. B.
The oxidation of beryllium. RESEARCH APPLIED IN INDUSTRY v. 15, p. 288–294, Jul 1962.

A study of oxidation resisting properties of Be using O and carbon dioxide in the presence of water vapor at temperatures ranging from 500-750° C. Influence of reactor radiation, temperature, exposure time and type of gas on the weight gain of Be sheet.

40. Perkins, F. C.
INTERMEDIATE-TEMPERATURE OXIDATION OF BERYLLIDES. Denver Univ. Denver Research Institute. Quarterly progress report, 1 Sep 1961–1 Mar 1962. Report DRI-2031. 8 Mar 1962. 32p. [Contract AT(11-1)-1092].

Oxidation characteristics of $ZrBe_{13}$, Zr_2Be_{17}, $NbBe_{12}$, and Nb_2Be_{17} were studied at temperatures between 1200 and 2000° F. Accelerated attack was observed in this temperature range compared with the neighboring temperatures. Thick wich oxide coatings were produced, and the reaction was sometimes accompanied by metallic disintegration. X-ray diffraction and metallography were used to study the products and manifestations of oxidation, and thermogravimetric curves are presented for $ZrBe_{13}$ and Nb_2Be_{17}.

41. Steele, J. R.
Beryllium corrosion. MATERIALS PROTECTION v. 1, no. 7, p. 59–62, Jul 1962.

Describes corrosion resistance of beryllium as being influenced by impurities in the metal. Impurities that could be derived from the manufacturing process of extracting beryllium from the ore are shown to lower corrosion resistance as measured by humidity tests. Variations in machined surface finishes, chemistry and the manufactured forms of product were examined under cyclic humidity conditions. Vacuum deposits of silver, nickel, zirconium, silicon monoxide, aluminum and titanium over beryllium were examined under similar conditions of humidity as well as for atmospheric corrosion at 1600° F. Also discusses electroplating techniques and compatibility of beryllium in organic cleaning solvents. Techniques of handling beryllium are discussed briefly.

42. Bear, W. R.
BERYLLIUM SHEET FABRICABILITY PROGRAM.
General Dynamics, Fort Worth, Texas. Report no. ERR-FW-064. 30 Dec 1960. 18p. [Contract AF 33(657)7248] ASTIA AD-275 962.

The fabricability and material properties program conducted on 0.060- and 0.020-in. beryllium sheet is discussed. Cutting and drilling techniques were investigated. Tensile tests were conducted to evaluate material uniformity. The primary objective of the program, the fabrication and testing of a plate-stringer panel to establish correlation between theoretical and actual design properties, was not attained due to inadequate ductility. The information obtained should advance the use of this type structural material in aerospace vehicles.

43. Christensen, L. M. and R. R. Wells
PROGRAM FOR THE DEVELOPMENT OF EXTRUDED BERYLLIUM SHAPES. Northrop Corp., Norair Division, Hawthorne, Calif. Final technical engineering report no. 62-7-644. Jun 1962. 301p. [Contract AF 33(600)-36931].

This manufacturing-process development demonstrates techniques by which aircraft and aerospace structural shapes of unalloyed beryllium can be extruded to a wall thickness of 0.060 inch − 0.001 inch. Pilot production of five twenty-foot long extrusions demonstrated good dimensional integrity and surface quality for structural channels 1.50 inches wide and 1.00 inch wide. To produce extruded beryllium shapes of aircraft quality, this program investigated the development of lubrication, die materials, heating, die design, and the effect of variable press speeds. A prime contributing factor to the success of the project was the change of technical approach from the glass lubrication system to Nuclear Metals newly developed refinement of the canned- or clad-extrusion technique, utilizing a "composite lubricant system. It was determined that composite lubrication of metallic and liquid (nonglass) lubricants is better adapted to utilization with beryllium than is bare glass-lubricated extruding.

44. Denny, J. P. and B. H. Hessler
BERYLLIUM CASTING. Beryllium Corp., Reading, Pa. Final technical documentary report, 19 Sep 1958 – 15 Jan 1962. Mar 1962. 73p. [Contract AF 33(600)-37902] (ASD TDR 62-930) ASTIA AD-277 602.

A manufacturing process was developed for the production of sound three inch diameter vacuum cast beryllium ingots suitable for fabrication. The casting technique relies on a thermal gradient within the mold (hot top, cold bottom) to control directional solidification of the metal and eliminate the center line shrinkage and cracking encountered in conventionally cast ingots. Ingots produced by this process were successfully converted on a laboratory scale into rolled sheet, extruded rod and tubing, and a forged cup. Four approaches to obtain grain refinement were evaluated during the course of the program: alloying, inoculation, mold vibration, and accelerated cooling through mold design. Of these, the latter was the most effective in achieving sound, relatively fine grained ingots. The mechanical properties of as-cast beryllium are less than can be obtained by powder metallurgy methods. Fabrication parameters may be adjusted to completely refine the cast columnar grain structure, resulting in a substantial improvement in properties.

45. Electro-machining beryllium. METALWORKING PRODUCTION v. 105, p. 56, 25 Jan 1961.

Electrical discharge machining of Be by a process in which the work is the anode and a spark is created between it and the cathode, the latter being a low-density tungsten electrode infiltrated with Ag. Trepanning techniques as a means of salvaging Be as solids rather than chips.

46. Formable sandwich panels. METAL INDUSTRY v. 100, p. 102 – 104, 9 Feb 1962.

Fabrication processes including rolling at 845-980°C, coring with paper, fiberglass reinforced plastic or metal, brazing, pressure welding, soaking and bonding of A55 Ti, 15-7 Mo stainless steel, Rene 41, Be, Mo, A110 AT Ti and 6Al-4V Ti and Al clad 2014 Al alloys. Applications as missile and aircraft components subjected to high temperature and compression and bending loads.

47. Giemza, C. J.
STRUCTURAL RESPONSE OF BERYLLIUM SHEET PRODUCED BY THREE FABRICATION METHODS. Martin Co., Baltimore, Md.
Final report, Feb 1960 to Mar 1961. Jun 1961.
47p. [Contract AF 33(600)-40648] (ASD-TR-61-87)

Hot-pressed, hot-upset and hot cross-rolled beryllium sheet was examined to assess their differences and advantages from a structural design viewpoint. Tension, notch tension, compression, bend ductility, and box-beam tests, with the main emphasis on factors which tend to embrittle beryllium, were conducted. The results showed that a hot cross-rolled beryllium sheet exhibits both high strength and high elongation in tensile tests but is relatively brittle when, as in bending, the stress is complex. Hot-pressed beryllium sheet, which is low in tensile strength and elongation, demonstrates an excellent capacity for accommodating complex stresses in bending without fracture. The hot-upset beryllium sheet exhibited the best characteristics possessed by both hot-pressed and hot cross-rolled beryllium, though to a lesser degree than the optimum of each. The differences in mechanical behavior among the three groups are apparently a function of the degree of preferred orientation. However, the amounts of impurity elements which were reported could have contributed significantly to the embrittlement of the hot-pressed and hot cross-rolled beryllium sheet. The data are presented as trend curves and, when appropriate, in tabular form.

48. Giemza, C. J.
STRUCTURAL RESPONSE OF BERYLLIUM SHEET PRODUCED BY THREE FABRICATION METHODS. Martin Marietta Corp., Baltimore, Md. Final report, Feb 1960–Mar 1961.
Dec 1961. 47p. [Contract AF 33(600)-40648; Proj. 1368] (ASD TR 61-87) ASTIA AD-273 707.

Hot-pressed, hot upset and hot cross-rolled Be sheets were examined to assess their differences and advantages from a structural design viewpoint. Tension, notch tension, compression, bend ductility and box-beam tests, with the main emphasis on factors which tend to embrittle Be, were conducted. The results showed that hot cross-rolled Be sheet exhibited both high strength and high elongation in tensile tests, but was relatively brittle when, as in bending, the stress was complex. Hot-pressed Be sheet, which was low in tensile strength and elongation, demonstrated an excellent capacity for accommodating complex stresses in bending without fracture.

The hot-upset Be sheet, exhibited the best characteristics possessed by both hot-pressed and hot cross-rolled Be, though to a lesser degree than the optimum of each. The differences in mechanical behavior among the 3 groups were apparently a function of the degree of preferred orientation. However, the amounts of impurity elements which were reported could have contributed significantly to the embrittlement of the hot-pressed and hot cross-rolled Be sheet.

49. Glorioso, S. V., D. P. O'Keefe, and S. W. Rogers
DEVELOPMENT OF BRAZED BERYLLIUM SANDWICH CONSTRUCTION. General Dynamics, Fort Worth, Texas. Report no. ERR-FW-043. Dec 1960. 27p. [Contract AF 33(657)-7248] ASTIA AD-276 008.

Beryllium sheet, .020 gage, was successfully prepared and brazed with steel and titanium honeycomb core to form a sandwich panel. Commercially available silver based alloys may be used for this purpose, however, an undesirable amount of diffusion or dissolution of the base metals may be experienced. The breakage associated with thin gage beryllium during handling or sawing is greatly reduced when the sheet is brazed into a sandwich. The full potential of brazed construction will not be realized until a braze alloy with properties compatible with beryllium has been developed.

50. Hockett, J. E.
Recent research in metal forming. APPLIED MECHANICS REVIEWS v. 15, no. 3, p. 157 – 166, Mar 1962.

Consideration of desirable mechanical properties of the materials and deformation mechanisms inherent in the deep drawing, a stretch forming, rolling, extrusion and high-energy rate forming of Al, Ti, Ta, Cb, Zr, V, Be, high strength steels and refractory metals. 89 references.

51. Hotchkiss, E. B.
Beryllium. MINING CONGRESS JOURNAL v. 48, no. 2, p. 105 – 107, Feb 1962.

Research on the mining, extraction and production of Be, beryllides and barylite. Review of potential applications and fabrication methods.

52. Krusos, J. N., et al.
SHEET BERYLLIUM – COMPOSITE
STRUCTURES. Aeronca Manufacturing
Corp., Middletown, Ohio. Interim technical documentary progress report no.
ASD-TR-7-845 (III), 1 Apr 1962–30 Jun
1962. Jul 1962. 259p. [Contract
AF 33(657)-7151; ASD Project 7-845].

This program is direct toward the design, development of manufacturing processes, testing, and evaluation of reinforced ceramic heat shields combined with load bearing honeycomb panel structure. The composite structure will be capable of withstanding surface temperatures in excess of 3000° F for one hour. The load bearing semi-monocoque structure will operate in temperature ranges suitable for beryllium, stainless steels and super alloys. The predominant development effort is in the application of beryllium to the load bearing structure. A ninety-inch section of a typical lifting body re-entry vehicle will be fabricated for test under simulated super-orbital re-entry environment. Preliminary work has been performed in the definition of environment, design analysis, materials selection, and component testing.

53. Machines turn violence into forming profits.
STEEL v. 151, no. 6, p. 64–70, 6 Aug 1962.

High energy rate forming including chemical explosive, electrohydraulic discharge, electromagnetic, pneumatic-mechanical forging techniques to form ... Be ... for aircraft and missile applications.

54. Mannas, D. A.
FABRICATION AND PROCESSING OF BERYLLIDES
AT GE-ANPD. General Electric Co. Aircraft
Nuclear Propulsion Dept., Cincinnati, Ohio. Report
NCDL-60-5-131. May 1960. 12p. [Contract
AT(11-1)-171]

Improved techniques were developed for the fabrication of beryllides by the conventional vacuum hot pressing process, and a broad investigation of the application of other fabricating processes was initiated. In the vacuum hot pressing process the limited purity of the base materials restricts the ultimate purity of the product. Extrusion, arc melting and casting, and induction melting and casting are discussed.

55. Metallurgists report progress in forming beryllium. IRON AGE METALWORKING INTERNATIONAL v. 1, p. 32–34, Feb 1962.

Formation of beryllium components by either pressing encapsulated powders or forging hot pressed metal. Review of canned powder, canned block, bare block, hot pressing and extrusion methods. Determination of average density, tensile and yield strengths, elongation and contraction. Uses for aerospace heat shields, gyroscope parts, moderators and reflectors.

56. Murphy, E. A. and J. G. Klein
HELICAL FINNED TUBE DEVELOPMENT.
Brush Beryllium Co., Cleveland, Ohio. Progress report, 16 Apr 1962 – 15 May 1962. 6p. [Contract AT-(40-1)-2912].

Tests were made of Be finned tubing produced by the "A" die design. Results are given for visual inspection, helium leak test, burst tests, and x-ray diffraction study of grain orientation.

57. Murphy, E. A. and J. G. Klein
HELICAL FINNED TUBE DEVELOPMENT.
Brush Beryllium Co., Cleveland, Ohio. Quarterly report, 16 Jan 1962. Technical report no. 258–235. 15 Apr 1962. 23p. [Contract AT(40-1)-2912].

Progress in the development of a process for the production of helical finned beryllium tubing by warm extrusion and drawing techniques is described.

58. Murphy, E. A. and J. G. Klein
HELICAL FINNED TUBE DEVELOPMENT.
Brush Beryllium Co., Cleveland, Ohio.
Quarterly report, 17 Oct 1961 to 15 Jan 1962.
Technical report no. 237-235. 15 Jan 1962.
21p. [Contract AT(40-1)-2912].

Results are presented of work toward development of a process for production of helical finned Be tubing by warm extrusion and drawing.

59. Murray, P. and D. T. Livey
PRODUCTION ON SINTERED COMPACTS OF BERYLLIA. (Assigned to United Kingdom Atomic Energy Authority) U. S. Patent 3,025,137. 13 Mar 1962.

A process is given for producing high-density beryllia compacts. The process comprises the steps of producing beryllia powder by calcining pure beryllium hydroxide at ~ 1250° C, cold-compacting the beryllia powder, heating the compact for 12 to 60 hr. at 1250 to 1400° C to bring about welding of the particles, and heating gradually to a sintering temperature of ≥ 1500° C.

JOINING

60. Automatic machine welds contacts to variety of parts. AUTOMATION v.9, p.80, May 1962.

Electrical contacts, stamped from normal-backed Ag tape, are joined to ... Be ... by a magnetic force bench welder.

61. Cline, C. L.
BRAZING BERYLLIUM FOR AEROSPACE APPLICATIONS. American Welding Society, 43rd Annual Meeting, 9 – 13 Apr 1962, Cleveland, Ohio. Technical Abstract.

Research on technique and materials including 6Al-4V Ti alloy and 303 stainless steel, using filler alloys of Ag, Li, Cu, Al, Mn, Zn, Cd and Ni. Tensile testing from room temperature to 1060 F indicates the highest ultimate tensile strength is achieved utilizing an Ag-Cu-Li filler.

62. Diffusion bonding
STEEL v. 150, p. 117 – 120, 2 Apr 1962.

Joining of Al alloys, Ti alloys, Be-Cu, Cu, steel, stainless steel, W, Be, graphite and monel by atom transfer to form a high strength bond. Effects of time, temperature, pressure, surface roughness and crystal lattice.

63. Hess, W. T., H. J. Lander, and S. S. White
Electron beam welding of beryllium. In PROCEEDINGS OF THE THIRD SYMPOSIUM ON ELECTRON BEAM PROCESSES. Cambridge, Mass., Alloyd Electronics Corp., 1961. p. 167 – 188.

An electron beam system for welding beryllium and the results obtained with it are discussed. Emphasis was placed on obtaining welds with shallow penetration and with strengths equivalent to the parent metal.

64. Hokanson, H. A., W. I. Kern, and S. L. Rogers
Electron beam welding of aluminum, beryllium and alumina. In PROCEEDINGS OF THE FOURTH SYMPOSIUM ON ELECTRON BEAM TECHNOLOGY. Cambridge, Mass., Alloyd Electronics Corp., 1962. p. 464 – 495.

Results of electron beam welding high-strength aluminum alloys, pure beryllium, and alumina to itself and to metals are reported. Welding was conducted with a 3 kw high-voltage, high-power density electron beam welding machine. The range of

machine parameters utilized in the aluminum welding program were: accelerating voltage to 150,000 v, beam current to 20 ma, and travel speeds to 120 inches per minute. Additionally, various beam oscillation and pulsing conditions were employed. Alloys welded were 7075 and 6061 aluminum and 85, 96, and 99.5% alumina. For the aluminum, particular emphasis was placed on inducing wettability by destruction of the oxide coating in the weld bead area and reduction of fusion-induced annealing or overaging by minimizing energy input through the use of minimal beam diameter and maximum possible welding speeds. For the alumina welding both to itself and to metals, primary emphasis was placed on eliminating cracking by the use of controlled pre- and post-heating. The major emphasis in the beryllium welding was placed on producing welds of maximum strength and ductility by minimizing energy input to the fusion zone.

65. Honeycombs bid for high temperature use.
CHEMICAL AND ENGINEERING NEWS
v.40, no.30, p.44, 23 Jul 1962.

Alumina, silica, zirconia and beryllia ceramics are foamed and bonded below 1000° F in a high strength honeycomb sandwich structure of stainless steel, Inconel or beryllium to withstand temperatures up to 3400° F.

66. Ikeuye, K. K.
Brazing beryllium oxide to pyrolytic graphite.
WELDING JOURNAL v.41, p.246S-349S, Aug 1962.

Three brazing alloys which will successfully wet and bond to both BeO and pyrolytic graphite were developed: 93 Ti – 7 Ni, 93 Ti – 7 Fe, and 53 Ti – 47 Cr. Ordinary brazing techniques employing vacuum or inert atmospheres are suitable for effecting BeO-to-pyrolytic graphite bonds with the three brazing alloys. The large differential in thermal expansion between BeO and pyrolytic graphite in the "a" direction resulted in high residual stresses in the brazed joint, and these residual stresses are sufficiently large in many instances to crack either or both of the base material components. Joint designs were developed which will prevent cracking in small (up to 1/2-in. long) joints, but these designs will not prevent cracking of one or the other of the base materials in longer joints.

67. Jahnle, H. A.
RESISTANCE SPOT WELDING BERYLLIUM SHEET. American Welding Society, 43rd Annual Meeting, Cleveland, Ohio. 9–13 Apr 1962. Technical Abstract.

Investigation into crack initiation during welding discloses impurities, temperature and fracture plane alignment as cuasative factors. Specimens subjected to tensile testing from room temperature to 800° F and metallographic examination.

68. MacPherson, B. M. and W. W. Beaver
NEW DEVELOPMENTS IN BERYLLIUM JOINING. American Welding Society, 43rd Annual Meeting, Cleveland, Ohio. 9–13 Apr 1962. Technical Abstract.

Effect of mechanical working including roll planishing, peening and forging; Mg, Al, Fe, Ge, Si and Be oxide impurities; Cu, Ag, Au, Ni and Fe, Co, Sn, Cr, Zn and Cd coatings on the strength, porosity, ductility and resistance to cracking of fusion welds.

69. Nadler, M. A. and G. Epstein
Bonded components in rocket motors. AEROSPACE ENGINEERING v.21, p.70–71, 86, 88–89, May 1962.

Thin strips of work hardened ... Be alloys are bonded by epoxy resin based adhesives to produce laminates having high strength to weight ratios for service in pressure vessels, rocket components and rifle liners.

70. Paprocki, S. J., E. S. Hodge, and P. J. Gripshover
Gas pressure bonding. MATERIALS IN DESIGN ENGINEERING v.55, no.3, p.14–15, Mar 1962.

Conditions of gas pressure bonding used for joining Be, Al, Mo, Cb, Zr, Ti, Cr and stainless steel and for consolidating uranium dioxide, uranium nitride, aluminum oxide, beryllium oxide and magnesium oxide powders and for cladding brittle materials.

71. Russell, D. V.
Developments in electron beam welding machines.
SHEET METAL INDUSTRIES v. 39, p. 495–499, Jul 1962.

Description of a low-voltage (30 kV) electron beam gun in terms of size, beam power, mobility and control means for velocity and position. Welds are shown for thick Al plate and a Be-Cu diaphragm.

72. Solomon, J. L.
New developments in electron beam welding machines. WELDING JOURNAL v. 41, no. 8, p. 719–727, Aug 1962.

Equipment for producing contamination free, leak proof weld joints with depth to width ratios as high as 22:1 in ... Be ... using the electron beam technique.

73. White, S. S., et al.
A study of electron beam welding. WELDING JOURNAL v. 41, p. 279s–288s, Jun 1962.

Electron beam welding of ... Be ...; relationship of the fusion zone width and interstitial gas content to the ultimate tensile strength, grain size, impact resistance and porosity.

74. White, S. S., et al.
A study of electron beam welding, Pt. 2.
WELDING JOURNAL v. 41, p. 329s–336s, Jul 1962.

Effects of weld width, temperature, atmosphere and heat flow on melting point, ultimate tensile strength and impact strength. Materials investigated include H-11 301 stainless steel, Be, Ti, Mo and W.

75. Whitson, E. M.
Vacuum brazing of stainless steel to beryllium.
METAL PROGRESS v.82, p.93–95, Jul 1962.

A new technique of brazing stainless steel to Be results in vacuum-tight joints twice as strong as those previously obtained. Pretreatment of the component surfaces as well as the brazing operation itself, is done in a furnace capable of maintaining a vacuum of 0.1 micron.

MINERALOGY

76. Angelelli, V.
BERYL IN THE REPUBLIC OF ARGENTINA.
Argentina. Comision Nacional de Energia
Atomica, Buenos Aires. Report no. 60. 1961.
48p. (In Spainish).

As an introduction to a description of Be ore deposits in Argentina, a general survey is given of beryl ore deposits, the characteristics of these deposits, the world production of Be, and the utilization of Be in the United States. From explorations in Argentina it was determined that there are beryl deposits in the form of pegmatites, principally in the mountains of Cordoba and of San Luis. Because of the characteristics of these deposits, it is almost impossible to define the Be reserves.

77. Bakakin, V. V. and N. V. Belov
Crystal chemistry of beryl. GEOKHIMIYA
no.5, p.420–433, 1962. (In Russian)

In a number of crystal structures with three-dimensional frameworks of Si, Al, Be tetrahedra and large cavities between these tetrahedra, (zeolites and similar minerals), a deficiency of positive charge resulting from the substitution (in the process of mineral growth in changing conditions) of some standard cations by cations of smaller charge or simply from their absence ("omission") is found. When the cavities are large enough a compensation of this deficiency is easily attained by introducing additional cations of required charge (not appearing in the standard formulas) with dimensions fitting the dimensions of existing cavities. Most frequently the cavities are too large and in order to avoid rocking of the introduced cations in their places new participants are needed. These may be ions or neutral particles which should form contacts between the cations introduced first and the insufficiently

saturated anions in the framework itself (their role is that of special props or stretchers). In many cases the role of these stretchers is not only a passive one. In particular when such stretchers as H_2O molecules – carriers of protons – are present and when specific features of the structures do not ensure close contact between the cations introduced first (which as a rule are of moderate sizes) and the anions in the Si, Al, Be framework, these cations may hand over their functions of compensators to the protons of the H_2O molecules. These cations remain bearers of the formal charge but the H_2O molecules [which in such cases should be denoted as $H^+ (HO)^-$], beside their basic role as props assume the functions of relay or buffer groups. One of the simplest structures of this kind is that of beryl, and a detailed study of its zeolitic properties predicts its predilection for Cs, Li, Na, its singular dislike for Rb, K, Mn, and its very high temperature of dehydration.

78. Morana, S. J. and G. F. Simons
Beryllium extracted by fluoride process.
JOURNAL OF METALS v. 14, no. 8, p. 571–574,
Aug 1962.

Description of fluoride process for extracting beryllium from beryl ore and for production of high purity metal and BeO; process is now in commercial production; other methods of producing beryllium are mentioned.

79. Peng, C. J., R. L. Tsao, and Z. R. Zou
Gugiaite, dicalcium beryllium silicate, a new
beryllium mineral and its relation to the melilite
group. SCIENTIA SINICA v. 11, no. 7, p. 977–988, 1962.

The specimens collected early in 1959 near the village of Gugia by one of the writers (R. L. Tsao) from the skarn rocks adjacent to an alkaline syenite, contained a number of well crystallized minerals. Preliminary laboratory study of one of the minerals showed that its optical properties match no known minerals, but its x-ray powder pattern is similar to that of melilites. A semiquantitative spectrochemical analysis showed the presence of beryllium. Further investigation revealed that this material was a new mineral having the composition of $Ca_2BeSi_2O_7$ and the same crystal structure as that of the melilite group. It is named gugiaite after the locality. The discovery of gugiaite is significant because it is the first beryllium mineral ever found in the skarn zones of alkaline rocks. Its relationship to the melilites is also interesting because Be plays the same role of substituting for (Mg, Al) in the melilite structure as Zn in hardystonite, $Ca_2ZnSi_2O_7$, which is also a member of the melilite group.

80. Pentelkov, V. G.
Correlation of granite intrusives on the basis of the determination of lithium and beryllium content in micas. GEOKHIMIYA no. 6, p. 497–500, 1962. (In Russian)

The systematic increase of the lithium (7.5 times) and beryllium content (6 times) in biotites of the mesozoic granite complex compared to Early Kaledonian and Hercynian complexes is shown. The possibility of an age correlation of intrusive complexes on the basis of a different content of rare elements in micas is admitted.

81. Aitken, E. A.
SINTERING KINETICS OF BERYLLIUM OXIDE. General Electric Co., Aircraft Nuclear Propulsion Dept., Cincinnati, Ohio. Progress report no. 1. Report no. DC 59-1-17. 17 Dec 1958. 11p. [Contract AT(11-1)-171).

Work in progress on studies pertaining to the kinetics of sintering of BeO is reported. A brief description is given of the various models by which BeO can sinter, and experimental data are presented which indicate a new mode of sintering unlike any of the mechanisms proposed before.

OXIDES

82. Aminoff, G.
On beryllium oxide as a mineral and its crystal structure. ZEITSCHRIFT FUER KRISTALLOGRAPHIE v. 62, p. 113–122, 1925. (In German) [English trans. by S. Shewchuck. Univ. of California. Lawrence Radiation Laboratory, Berkeley. UCRL-Trans-826(L) 24p.]

The occurrence of BeO crystals in the mineral swedenborgite [$NaSb(AlO_3)_2$] is reported. The crystal form, optical properties, and crystal structure are described.

83. Bellamy, B., T. W. Baker, and D. T. Livey
Lattice parameter and density of beryllium oxide determined by precise x-ray methods.
JOURNAL OF NUCLEAR MATERIALS.
v. 6, no. 1, p. 1–4, 1962.

Six samples of beryllium oxide were prepared by calcination in air of hydroxide, sulphate and oxalate to give powders of varied purity. The lattice parameters were calculated from x-ray patterns obtained with a precision camera and found to be equal within the errors of measurement. The parameters of one sample were determined more accurately using a least squares method and a Mercury computer to give the following values at 21° C:

$$a = 2.6979 \pm 0.0001 \text{ Å},$$
$$c = 4.3772 \pm 0.0002 \text{ Å}.$$

The corresponding density is $3.0100 \pm 0.0003 \text{ g/cm}^3$.

84. Livey, D. T. and J. Williams
Materials. Pt. 9. Aspects of the technology of beryllium and beryllia. In PROGRESS IN NUCLEAR ENERGY. SERIES 5. METALLURGY AND FUELS
v. 3, Chap. 1. N. Y., Pergamon, 1961. p. 139–157.

Summary of papers, presented at the Second Conference on the Peaceful Uses of Atomic Energy, dealing with Be technology including melting and casting procedures, CO_2 corrosion tests at 500-700° C., methods for sheathing in Be and powder metallurgy procedures for BeO.

85. Swindeman, R. W.
THERMAL STRESSES IN SOLID CYLINDERS OF BERYLLIUM OXIDE. Oak Ridge National Laboratory, Tenn. Report ORNL-TM-123. 6 Apr 1962. 18p. (Contract W-7405-Eng-26).

The problem of fracture of solid cylinders of BeO due to stresses induced by transient temperature differences is considered. The stress analysis for this case, the appropriate fracture theories, and the related properties of BeO are presented and used to estimate the conditions under which solid cylinders of BeO should crack. On the basis of available data and assuming that the maximum principal stress controls fracture, BeO cylinders should fail on quenching from 1000° C if $r_m h$ (radius of cylinder times film coefficient) is greater than 0.01 cal $sec^{-1}(°C)^{-1} cm^{-1}$. An additional assumption used in this calculation was that the tensile strength is 30,000 psi and independent of temperature over the temperature range under consideration. A testing program required to evaluate BeO for use in reactors is outlined in general terms.

POWDER METALLURGY AND CASTING

86. Brown, R. J.
High purity BeO for electronics. CERAMIC AGE v.78, no.2, p.51–56, Feb 1962.

BeO ranging from 85-99% purity is wet blended for dry pressing, is oppressing and extrusion. It is air fired in a dielectric oven. Thermal conductivity, dielectric properties, strength and ease of metallizing are characteristics of high purity BeO ceramics.

87. Jenkins, I.
Powder metallurgy. MACCHINE v. 16, no. 12, p. 1241–1249, Dec 1961. (In Italian)

Fabrication and sinterizing of W, Cu, Ag, C, Ta, Fe, Mo, Be and Ni powders and application in making filters, bearings and drills. Determination of magnetic permeability, porosity and density of sinterized products.

88. Loewenstein, P.
The extrusion of beryllium. CURRENT
ENGINEERING PRACTICE v.4, p.16–20, Feb 1962.

Hydrostatic pressing, rolling and extrusion of Be powder with subsequent canning of the billet with carbon steel. Analysis of extrusion forces and metal flow mechanisms. Data are given for preferred orientation and ductility as a function of the extrusion ratio. Comparative microstructures are given showing the relative grain size of extruded and cast Be.

89. Muvdi, B. B.
Internal structures of rolled, pressed and
extruded beryllium compacts. METAL PROGRESS
v.82, p.140, 142, 144, Jul 1962.

Compacts of Be powder were fabricated by five different processes; upsetting while hot gives the best combination of properties and is superior to hot pressing and random rolling.

90. Nakatani, H.
The effect of the particle size of sintered beryllium
powder on its apparent density and electrical resis-
tivity. DENKI SHIKENSHO IHO v.26, p.278–284,
Apr 1962. (In Japanese)

The effect of the particle size on the apparent density and electrical resistivity in sintered beryllium was studied. The temperature coefficient of the electrical resistivity of sintered, rolled and annealed beryllium plate was determined. The higher apparent density of compact was obtained for powder containing coarses particles before sintering than for powder containing finer particles after sintering. The value of the temperature coefficient of electrical resistivity from 0 to 100° C is 6.3×10^{-3}.

91. Oya, S. and U. Honma
Gas absorption in aluminum bronzes. IMONO
v. 34, p. 106–112, Feb 1962. (In Japanese)

Effectiveness of various impurities such as Be and Ca used to prevent gas pickup on the Al bronze casting surface.

PROCESSING

92. Bruin, H. J. de, D. Kairaitis, and R. B. Temple
Extraction of anionic beryllium complexes by
tri-iso-octylamine. AUSTRALIAN JOURNAL
OF CHEMISTRY v. 15, no. 3, p. 457–466, 1962.

The extraction of beryllium from aqueous solution by long-chain tertiary amines has been observed in the presence of ligands giving rise to anionic complexes. The nature of the oxalate complex extracted by solutions of tri-iso-octylamine in chloroform has been studied in detail and the species formed in the organic phase were shown to have the composition $Be(C_2O_4)_2 . \{NH(i\text{-}C_8H_{15})_3\}_2$. The complexes formed in aqueous solution between beryllium and several anionic complexing agents have been examined by the method of pH-titration. Conditional stability constants have been obtained for the complexes formed with oxalic, malonic, maleic, succinic, phthalic, and salicylic acids. Differences in their extractabilities can be explained semiquantitatively with the help of the stability constants and the acid association constants of the complexing agents.

93. Bueggs, A. A., et al.
A PRELIMINARY REPORT ON THE SOLVENT
EXTRACTION OF BERYLLIUM FROM LOW GRADE
SULPHATE AND FLUORIDE SOLUTIONS. Gt. Brit.
National Chemical Laboratory, Teddington, Middlesex,
England. Report no. NCL/AE-172. Dec 1958. 19p.

Beryllium was extracted from sulfuric acid leach liquors using kerosene solutions of both di-(2-ethylhexyl) hydrogen phosphate and monododecyl dihydrogen phosphate. Ferric iron and aluminum were also extracted, the order of preference being Fe > Be > Al. Iron and aluminum once extracted are not readily displaced by

beryllium. The stripping of all three metals from the phosphate esters was examined briefly. It was not found possible to extract beryllium from fluoberyllate solutions with the phosphate esters tested. Kerosene solutions of high molecular weight amines did not extract beryllium from fluoberyllate or from sulfate solutions to any useful extent under the conditions studied.

94. Chauvin, G., H. Coriou, and J. Hure
Electrorefining of nuclear metals in molten
salt bath. METAUX CORROSION-INDUSTRIES
v.37, no.439, p.112–126, Mar 1962. (In French)

Industrial electrorefining of commercial uranium, beryllium, plutonium, thorium and titanium by chloride and fluoride salt electrolytic baths. Determination of the influence of humidity and concentration of electrolyte on resulting purity.

95. Experimental hydrostatic extrusions point to new
production techniques. MODERN METALS
v. 18, no.7, p.68, 70, 72, Aug 1962.

Experimental extrusions in aluminum, copper, steel, beryllium, and yttrium have been produced by a process that employed hydrostatic pressure in the extrusion container in place of the container of the conventional extrusion ram. The value of the use of a liquid medium for transmitting hydrostatic pressure to the extrusion billet is discussed.

96. Extrusion of non-ferrous metals. INDUSTRIAL
HEATING v.29, no.7, p.1266–1270, 1278, Jul 1962.

Procedures for extruding non-ferrous metals including ... Be ... Determination of factors, influencing tool and die component life, and mechanical and structural properties of the extruded alloy.

97. Houle, M. C. and R. L. Coble
Ceramographic techniques. Pt. 1. Single phase, polycrystalline, hard materials.
AMERICAN CERAMIC SOCIETY BULLETIN
v.41, p.378–381, Jun 1962.

Preparation of polished sections of hard single phase ... BeO ... by various techniques of mounting, grinding, polishing and etching for microscopic examination in reflected light.

98. Hyde, K. R. and M. J. Waterman
INPROVEMENTS IN OR RELATING TO EXTRACTION OF BERYLLIUM FROM BERYL ORE. British Patent No. 896,812. 16 May 1962.

A process for extracting Be from beryl ore is outlined in which only a minor proportion of the Al in the ore is also extracted. The process comprises leaching the ore with an aqueous solution containing 0.2 to 5 $\underline{N}$ H_2SO_4 and 0.1 to 0.5 $\underline{N}$ HF at a temperature between 200° C and the critical temperature of the leaching solution, preferably at least 300° C.

99. Poston, A. M., Jr., J. V. Batty, and H. L. Gibbs
USE OF RADIOACTIVE TRACERS IN BERYLLIUM EXTRACTIVE METALLURGY RESEARCH. U. S. Bureau of Mines. Report of Investigations 4980. 1962. 10p.

Radiometric analysis using Be^7, Fe^{59} and Al^{26} radioisotopes for control of fusion, extraction, leaching and purification of Be in ores, concentrates and pregnant liquors.

100. PRODUCTION AND AVAILABILITY OF SOME HIGH-PURITY METALS. Battelle Memorial Institute. Defense Metals Information Center, Columbus, Ohio. DMIC Memorandum No. 76. Dec 1960. 58p. (Pb 161226).

Electrolysis, leaching, vacuum distillation and reduction of Be ... and the effect of the method preparation on the purity of the product.

101. Rare metals are a challenge to metallurgy. AUSTRALASIAN MANUFACTURER v.45, p.68–71, 4 Mar 1961

Extraction and refining of Be from beryl by fluorination, fusion and electrolysis and of Zr from zicron by chloride conversion process and reduction with Mg or Na. Data are given for mechanical and physical properties, corrosion resistance and neutron absorption cross section.

102. Schimmel, F. A. RECLAMATION OF BERYLLIUM CHIPS BY ELECTROLYSIS. Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn. Progress report to 31 Jul 1961. Report Y-1380. 18 Jan 1962. 31p. (Contract W-7405-eng-26).

Beryllium in the form of either dendrites or platelets was produced in a 100-ampere cell using $LiCl - BeCl_2$ electrolyte. The product was spectrographically as pure as a commercially produced Super-Fine grade material. A pilot plant is being built with a refining cell capacity of 2000 amperes.

103. Schofield, M. A century of beryllium and magnesium extraction. METAL TREATMENT AND DROP FORGING v.29, p.233–236, Jun 1962.

Historical review of extraction processes for Me and Mg compounds including electrolysis and reduction by Na, Mg, CaC_2, C and ferrosilicon.

104. Spangler, G. E., M. W. Herman, and E. J. Arndt
PREPARATION AND EVALUATION OF HIGH PURITY BERYLLIUM. Franklin Institute. Laboratories for Research and Development, Philadelphia, Pa. Final report, 2 Nov 1960 – 1 Nov 1961. Report no. F-A2476. 1 Nov 1961. 59p. (Contract NOw 61-0221-d) ASTIA AD-273 621.

Zone refining procedures for vertical floating-zone type zone melting of Be and described. Single crystals prepared from zone melted Be were tested in tension with their orientation arranged to yield basal plane slip. The critical resolved shear stress varied from 2400 to 400 psi, decreasing with increased purification; the glide strain varied from 16 to 220% increasing with increased purification. Procedures for the rolling of several single crystals of Be are described and the results of recrystallization studies on them are presented. Limited slip, observed when basal flow occurs in polycrystalline material, appears to result from grains constraining one another during deformation. This mechanism of fraction is expected to operate independently of the level of purity of Be.

105. Spangler, G. E., et al.
PREPARATION AND EVALUATION OF HIGH PURITY BERYLLIUM. Franklin Institute. Laboratories for Research and Development, Philadelphia, Pa. Quarterly progress report for 2 Oct 1961 – 2 Apr 1962. Report no. Q-B1933 1–2. 2 Apr 1962. 42p. (Contract NOw 62-0536-d) ASTIA AD-275 750.

The production of high purity Be and its deformation and fracture characteristics are being studied. It was demonstrated that the extent to which the basal plane can glide, within the restriction of the type of tensile test, is related to the amount of impurities present in the Be. The limited ductility of the polycrystalline material apparently results from the constraining effects of neighboring grains upon one another rather than as a result of the basal planes being unable to sustain flow without cracking. It is felt, however, that the decrease in yield strength and work hardening observed in the zone refined single crystals will tend to reduce the tendency for crack formation resulting from non-homogenous basal slip. The preparation and evaluation of Be single crystals of higher purity through the use of higher purity starting materials

will be made. Another phase will be devoted to an evaluation of the effects of re-alloying zone refined Be with selected impurities. Transmission electron microscopy studies of thin films of zone refined beryllium will also be conducted. A final phase will be devoted to the determination of residual resistivity ratios of zone refined and re-alloyed beryllium by means of the eddy current technique.

106. Truesdale, R. S., et al.
INVESTIGATION OF THE EFFECTS OF PROCESSING VARIABLES AND FABRICATION TECHNIQUES UPON THE PROPERTIES OF INTERMETALLIC COMPOUNDS. Brush Beryllium Co., Cleveland, Ohio. Final technical documentary report, 1 Apr 1960 to 30 Sep 1961. Jun 1962. 269p. [Contract AF 33(616)-7108] (ASD-TDR-62-476)
ASTIA AD-278 807.

Intermetallic compounds of $NbBe_{12}$, Nb_2Be_{17}, Nb_2Be_{19}, and Ta_2Be_{17} were fabricated by uniaxial pressing and sintering techniques. Results of sintering studies on Nb_2Be_{17} are presented and discussed. The effects of particle size, stoichiometry, temperature, and time upon the sintered density, grain size, and strength of Nb_2Be_{17} are described. A modulus of rupture evaluation is made on Nb_2Be_{17} up to 2750° F, and results of tensile, Young's modulus, thermal conductivity, and oxidation studies are discussed. The feasibility of scaling-up to large and complicated shapes by isostatic pressing, slip casting, extrusion, hot pressing, and flame spraying is demonstrated. The temperature-pressure-flow characteristics of several berylli..s at temperatures of 2750° to 3050° F are evaluated together with microstructural stability. The metallurgical fabrication techniques of forging, forming, and rolling as applied to Nb_2Be_{17} are examined.

107. Vetejska, K., and J. Mazacek
Separation of beryllium from impurities by means of Czechoslovakian ion-exchange resins. In PRACI USTAVU PRO VYZKUM RUD, 1958-1959, 1960. v. 3, p.160-171. (In Czech).

A study was made of Be, Fe and Al sorption on anionites OAL and MFD and on cationite FN in HCl and H_2SO_4 medium. It was found that in HCl medium Be is

separated from Fe on anionite OAL at a concentration of 8N HCl; in H_2SO_4 medium sorption takes places equally for all elements. The process is also the same on anionite MFD. On cationite FN the sorption of Be and Al only is observed in 0.5–0.7N H_2SO_4 medium.

PROPERTIES

108. Burk, M.
Thermal expansion of ceramic materials at -200 to 0° C. AMERICAN CERAMIC SOCIETY. JOURNAL v.45, p.305–306, Jun 1962.

Dilatometric measurement of low temperature thermal expansion in alumina, magnesia and beryllia specimens. Effect of lattice, spinel and glass phase structure and composition on the thermal expansion coefficient as a function of temperature.

109. Campbell, J. E.
COMPILATION OF TENSILE PROPERTIES OF HIGH-STRENGTH ALLOYS. Battelle Memorial Institute. Defense Metals Information Center, Columbus, Ohio. DMIC-Memo-150. 23 Apr 1962. 46p. [Contract AF 33(616)-7747].

Tensile properties of high-strength alloys and beryllium from -423 to 4000° F are presented. The upper limits of the yield strength to density ratios for these alloys within the range of possible service temperature are illustrated. The temperature and time effects are combined in the Larson-Miller parameter for 0.2% offset yield strength or 0.2% plastic creep strain for limited creep data. The time for 0.2% offset yield strength determination is assumed as 0.01 hour. Materials reported on include beryllium, steel, stainless steel, sintered aluminum product alloys, and alloys of aluminum, cobalt, iron, magnesium, molybdenum, nickel, niobium, tantalum, titanium, and tungsten.

110. Crawford, R. F., and A. B. Burns
STRENGTH, EFFICIENCY, AND DESIGN DATA FOR BERYLLIUM STRUCTURES. Lockheed Missiles and Space Co., Sunnyvale, Calif. Report for Feb 1960–Dec 1961, on Design Technologies and Structural Configuration Concepts for Aerospace Vehicles. Report no. 2-47-61-3. Feb 1962. 516p. [Contract AF 33(616)6905] (ASD Technical Report 61-692).

The purpose of this study program was to investigate the design capabilities of beryllium as a structural material and to derive and develop structural design curves and related data for efficient structural design with beryllium. The metal beryllium is believed to have high potential for aerospace structures, but is not extensively considered in design applications at the present time because of uncertainties as to the proper design procedures. This report presents information based on studies and tests which clearly shows that beryllium now may be designed with confidence into many types of load-carrying structures, using well-known methods of structural analysis and appropriate margins of safety. The resulting beryllium structures are shown to be considerably lighter than identical structures fabricated from other metals, and these structures are attainable with currently available beryllium mill products.

111. Crossley, F. A.
DEVELOPMENT OF DUCTILE BERYLLIUM COMPOSITES. Illinois Institute of Technology, Chicago. Armour Research Foundation. Bimonthly report no. 5, 18 Sep 1961–17 Nov 1961. Report ARF-2212-5. 17 Nov 1961. 11p. (Contract NOw-61-0370-c) ASTIA AD-266 424.

Further efforts directed to the development of ductile composites consisting of Be particles in a ductile matrix of compositions selected from the Al–Ag system are reported. Efforts are being directed toward making relatively large (2 1/2 × 1 1/4 × 1 1/4 in.) compacts from which specimens will be prepared for tensile test evaluation.

112. Ewing, C. T., *et al.*
Thermal conductivity of refractory materials.
JOURNAL OF CHEMICAL & ENGINEERING
DATA v. 7, p. 251–256, Apr 1962.

A semitheoretical treatment of heat transfer in polycrystalline dielectric ceramics is presented in order to preduct the thermal properties of the refractories. Thermal conductivity-temperature curves were determined for 23 high-temperature materials: beryllia, six beryllia – beryllium cermets, a beryllia – beryllium – molybdenum cermet, silicon carbide, three silicon carbide – graphite mixtures, boron nitride, a boron nitride – graphite mixture, four grades of beryllium, and the beryllides of molybdenum, zirconium, titanium, and niobium. Except for beryllium, measurements were made up to 950 or 1000° C. Measurements were made by an absolute method requiring a precise measurement of heat input and a comparative method using a material of known conductivity to measure the heat flow.

113. Gasc, C.
CONTRIBUTION TO THE STUDY OF THE
CRYSTALLINE TEXTURE AND OF THE
MECHANICAL PROPERTIES OF CONVERTED
BERYLLIUM. Ministere de l'Air. France.
Publications Scientifiques et Techniques
No. 386. Apr 1962. 97p. (In French)

An attempt has been made to specify the parameters that influence the development of the desired qualities in sheets of beryllium. The comparison of various textures studies permits an approach to the problem of beryllium formation which, in turn, leads to interesting conclusions as to how the metal develops deformities at high temperatures. Also, mechanical tests were made to determine detailed information on the complex causes of brittleness in beryllium at an ambient temperature. The preponderant influence of the texture, coarseness of grain, and distribution of impurities was revealed.

114. Gelles, S. H., et al.
THE STABILITY OF THE HIGH-TEMPERATURE PHASE IN BERYLLIUM AND BERYLLIUM ALLOYS. Institute of Metals. Conference on Metallurgy of Beryllium, London, October 1961. Preprint no. 33, 1961. 11p.

Differential thermal analysis was applied to alloys of Be with Ba, Ce, Cr, Co, Cu, Fe, La, Mn, Ni, Nb, Pd, Pt, Si, Ag, V, Zr, Ni-Co, Ni-Cu, Ni-Fe, Ni-Pd, Ni-Co-Fe, and Ni-Co-Mn. Co, Cu, and Ni gave an enlarged beta-phase field at high temperature. The upper $\beta \rightarrow$ a solvus transition temperature correlates with electron/atom ratio for the systems Be-Co, Be-Cu, Be-Fe. In attempts to retain the beta-phase by quenching the lowest transformation temperature observed was 242° C in a Be-8% Ni alloy. This alloy gave a 19% reduction in area on testing at 1070° C compared with zero for pure Be.

115. Giemza, C. J.
AN EVALUATION OF A ROLLED BERYLLIUM SHEET. Martin Co., Baltimore, Md. Report RM-57. Nov 1959. 27p.

An evaluation was made of the mechanical characteristics of an experimental beryllium sheet. The tests comprised tension, compression, notch tension, fatigue, shear, bearing and flexure. Particular attention was given to tests which would reflect the resistance of the sheet to embrittling conditions. Although the structural potential of beryllium is evident, the brittle character and anisotropy of the rolled sheet, which have been shown by this evaluation, do not satisfy the minimum standards for aircraft and missile structures.

116. Glenny, R. J. E.
Progress report on the new structural metals. NEW SCIENTIST v. 14, p. 104–107, 19 Apr 1962.

Physical and mechanical properties are given for Be ... Melting, forming and welding procedures are outlined. Possible future applications are suggested.

117. Grain, C. F., and W. J. Campbell
THERMAL EXPANSION AND PHASE INVERSION OF SIX REFRACTORY OXIDES. U. S. Bureau of Mines. College Park Metallurgy Research Center, Md. Report BM-RI-5982. Aug 1961. 25p.

Thermal expansion and phase inversion measurements are reported on BeO, CaO, TiO_2, ZrO_2, HfO_2, and ThO_2.

118. Hodge, W.
BERYLLIUM FOR STRUCTURAL APPLICATIONS: A REVIEW OF THE UNCLASSIFIED LITERATURE, 1958–1960. Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio. DMIC Report 168. 18 May 1962. 219p. [Contract AF 33(616)-7747] ASTIA AD-278 723.

Progress of work on the physical and process metallurgy of beryllium during the 3-year period 1958–1960 is reviewed.

119. Hoffman, G. A.
THE POTENTIAL OF BERYLLIUM IN SUPERSONIC COMMERCIAL AIRCRAFT. RAND Corp., Santa Monica, Calif. Memo. no. RM-3094-PR. May 1962. 21p. [Contract AF 49(638)700; Proj. RAND] ASTIA AD-275 519.

A structural comparison is made of Be with the best alloys of Al, Ti, and steel for a variety of applications in supersonic transports. Such applications include components whose design is governed by tension criteria, by compression in stiffened and sandwich panels, and in unstiffened plates, and by notched behavior, all over the temperature range to be encountered in future aircraft. It is inferred that a Be structural part might weight from 1/4 to 1/2 less than the equal-function part made of more conventional metals. Calculations of the economics of Be usage in aircraft

follow, consisting of several derivations of the work-in-use of the weight reduction in commercial transports obtained by substituting a lighter-weight, but costlier, Be component. It is concluded that Be would offer many economic and weight-reducing advantages for transports.

120. Hollis, W. S.
Whiskers – a fabricating medium of the future?
METALWORKING PRODUCTION v. 106, p. 71–73,
75, 6 Jun 1962.

Production of whiskers using Fe, Cu, Be, alumina, graphite, Se, SiC, Sn and boron carbide by electrolytic deposition, vacuum heating under Hg pressure at 700-1000° C, vapor condensation and hot dipping. Effect of atomic structure dislocations on whisker strength and influence of screw dislocations on growth rate.

121. Hug, H. and H. Bichsel
Effect of small amounts of beryllium on
recrystallization of very pure aluminum
(Raffinal). METALL v. 16, no. 3, p. 193–198,
Mar 1962. (In German)

Tensile testing and microscopic, electron microscopic and x-ray investigation of 400-600° C hot rolled specimens of pure Al and of Al containing 0.046% Be after annealing at temperatures from 230-350° C.

122. Hunt, J. G. and R. B. Russell
Texture in hot-extruded BeO. JOURNAL OF
NUCLEAR MATERIALS v. 6, p. 142–143, May–Jun
1962. (In English)

In order to determine whether hot-extruded hexagonal close-packed (hcp) BeO as a $(10\bar{1}0)$ fiber texture similar to hcp metals like Be, Ti, and Zr, som 13 3-to-5-mm diameter hot-extruded BeO rods were examined in composite for texture by x-ray diffraction. It was found that, since the highest pole densities, corresponding to 9.5 to 13% lie within the area bounded by the poles $10\bar{1}0$, $10\bar{1}1$, $21\bar{2}2$, and $11\bar{2}0$, the texture could be considered a degenerate $(10\bar{1}0)$ fiber texture involving about 80% of the crystallites.

123. Jacobson, M. I. and Almeter, F. M.
TENSILE FAILURE OF QMV BERYLLIUM FROM ROOM TEMPERATURE TO 870° C.
Institute of Metals. Conference on Metallurgy of Beryllium, London, October 1961. Preprint no. 35. 1961. 12p.

The theories of grain-boundary migration and intercrystalline cracking are reviewed. Tensile tests on Be containing 0.85-2.0% BeO_2 were undertaken from 20 to 870° C. The specimens were subsequently examined metallographically. The observed changes in ductility and mode of deformation with temperature are interpreted in terms of current fracture theories.

124. Koda, S. and S. Morozumi
Behavior of inclusions in beryllium under compression at room temperature. JOURNAL OF NUCLEAR MATERIALS v-6, no. 1, p. 5–12, 1962.

The behavior of inclusions in the vacuum-melted beryllium specimens which were made from pebble and flake metals with or without addition of aluminum, silicon, beryllium oxide, or air has been investigated. Inclusions are round- and stringer-shape aluminum-, silicon-, and iron-rich phases, angular carbide phase, cluster of oxide, and nitride needle. Inclusions of all kinds of shapes except some small ones interact with slip and twin deformation. The following phenomena have been observed: (a) Coherent deformation of the aluminum-rich phase; (b) separation of inclusions from the matrix; (c) cleavage of inclusions; (d) initiation of new slip and twinning in the matrix at the boundary between the inclusion and the matrix; (e) occurrence of cracks from the boundary into the matrix; (f) when a crack approaches inclusions including a cluster of oxide, the crack is developed, with further deformation accompanying the separation of the inclusions from the matrix and/or the cleavage of the inclusions; (g) however, the crack which causes the metal to fracture is not necessarily a crack such as is developed by an inclusion.

125. Krusos, J. N., et al.
BERYLLIUM COMPOSITE STRUCTURES.
VOLUME I – DESIGN AND APPLICATION.
Aeronca Mfg. Corp., Middletown, Ohio.
Final technical engineering report. 4 Feb 1960 – 31 Aug 1961. May 1962. 179p. [Contract AF 33(616)-7050] (ER-532, v. 1; ASD-TR-61-706, v. 1).

Design information is presented for beryllium and ceramic composite structures for reentry vehicle applications. The volume includes a summary of materials and process developments for beryllium panels and heat shield ceramics, analytical evaluations and discussion of application of insulated structural concepts to reentry vehicle systems. Also, included are the results of panel tests in the severe environments of turbojet and ramjet exhausts. Data suitable for preliminary design considerations are presented for three reinforced heat shield ceramic foams: alumina, silica and zirconia. Beryllium sandwich panels constructed in the course of the program are described with regard to fabrication potential and performance features in aerospace structures.

126. Krusos, J. N., et al.
BERYLLIUM COMPOSITE STRUCTURES.
VOLUME II – MATERIALS AND PROCESSES.
Aeronca Mfg. Corp., Middletown, Ohio.
Final technical engineering report. 4 Feb 1960 to 31 Aug 1961. May 1962. 324 p. [Contract AF 33(616)-7050] (ASD-TR-61-706, v.II)
ASTIA AD-278 526.

Processes were developed for fabricating beryllium structural shapes to operate in environments encountered by aerospace vehicles during reentry. Beryllium sheet process development work included cutting, chemical milling, forming and brazing of sandwich panels consisting of stainless steel or superalloy honeycomb and beryllium faces. Ceramic heat shields were developed to resist temperatures in excess of 3000° F. The combination of ceramic heat shields and beryllium or superalloy sandwich structure was used to fabricate lightweight insulated components including flat and curved panels, and leading edges. The ceramic materials used in the heat shield were developed under this contract and consisted of lightweight foams, alumina, silica and zirconia.

127. **Krusos, J. N.**
SHEET BERYLLIUM COMPOSITE STRUCTURES.
Aeronca Mfg. Corp., Middletown, Ohio. Interim
technical engineering report. 1 Oct–31 Dec 1961.
ASD TR-7-845, v. 1. Jan 1962. [Contract
AF 33-(657)7151; Proj. 7-845] ASTIA AD-273 596.

This program involves design, development of manufacturing processes, testing and evaluation of reinforced ceramic heat shields combined with honeycomb panel load bearing structure. The ceramic heat shield is designed to reject approximately 98% of the incident heat flux by radiation at the surface and is capable of withstanding environments in excess of 3000° F for one hour. The load bearing sem-monocoque structure operates in temperature ranges suitable for stainless steels, super alloys and beryllium. A 90-in. long test section representing a portion of a typical lifting body reentry vehicle will be fabricated and tested.

128. Lippman, D. and M. P. Stoltenberg
HEAT STORAGE MATERIALS. Lithium Corp.
of America, Inc., New York, N. Y. 1 Jun 1961.
108p.

Molecular weight, density, melting point, boiling point, heat capacity, heat of fusion, heat of vaporization, thermal conductivity and enthalpy for Be, Be_2C, BeF_2, Be_3N_2, BeO, Be_2O_3, B, B_4C, BN, C, Li, Li_2C_2, LiF, LiOH, $LiNO_3$, Li_3N and Li_2O at elevated temperatures.

129. Lubeshkin, V. A. and V. P. Andronov
Flakes and bubbles in metallic simifinished
products. METALLOVEDENIE I
TERMICHESKAYA OBRABOTKA METALLOV
no. 5, p. 36–38, 1962. (In Russian)

Fermation of bubbles in beryllium bronze strip during annealing in an ammonia medium as caused by microscopic flakes. Study of the relationship between thickness of the strip and flake distribution, with determination of bubble and flake concentration by breaking tests.

130. Mishima, Y.
High strength copper-aluminum-beryllium alloy. TOKYO UNIVERSITY. FACULTY OF ENGINEERING. ENGINEERING RESEARCH INSTITUTE. ANNUAL REPORT v.20, p. 165 – 170. Mar 1962. (In Japanese)

Investigation of the microstructure, hardenability and workability of the Cu-Al-Be ternary system using variable compositions (Al 1.5-7.5 w/o and Be 0.5-2.5 w/o).

13. Nuclear Metals, Inc., Concord, Mass.
FUNDAMENTAL AND APPLIED RESEARCH AND DEVELOPMENT IN METALLURGY.
Progress report to United States Atomic Energy Commission, Mar 1962. Report NMI-2105. 24 May 1962. 18p. [Contract AT(30-1)-2784].

Investigation was continued to relate high-temperature properties of refractory metal alloys to parameters such as microstructure, atomic structure, and position of the elements in the periodic table. Selected compositions from binary systems containing Hf, Os, Re, and Ru are being investigated. Data on tensile and hot hardness properties of Mo, Mo–Re, Ta–Re, Ta–Ru, and W are given. Continued work is reported on corrosion of Zr alloys, mechanism of failure of thick oxide films, the effects of foreign ion incorporation into ZrO_2 lattices, and zone refining of flake and distilled Be.

132. Nuclear Metals, Inc., Concord, Mass.
FUNDAMENTAL AND APPLIED RESEARCH AND DEVELOPMENT IN METALLURGY.
Progress report to United States Atomic Energy Commission for Feb 1962. Report NMI-2104. 4 May 1062. 35p. [Contract AT(30-1)-2784].

Research progress is reported on studies of high-temperature properties of refractory metal alloys, fundamental studies of the corrosion of zirconium alloys,

irradiation behavior of metastable beta phase alloys, and fundamentals of single crystal deformation in zone-refined beryllium.

133. Ohta, K. and Y. Kobayashi
Magnetic properties of the iron-beryllium compounds with the hexagonal structure. KOBAYASHI RIGAKU KENKYUSHU HOKOKU v. 11, no. 3, p. 61–64. Jul–Sep 1961. (In Japanese)

Preparation of polycrystalline specimen (beta-phase) Fe-Be compounds with 71.0 and 68.0 at. % of Be in vacuum induction furnace. Data are given for crystallographic and magnetic properties and magnetic anisotropy. Included are temperature levels in K°, Curie temperature, C° and liquid O level and the system phase diagram.

134. Pemsler, J. P., R. W. Anderson, and E. J. Rapperport
SOLUBILITY AND DIFFUSION OF GASES IN BERYLLIUM. Nuclear Metals, Inc., Concord, Mass. Final report. Report NMI-9815. 14 Mar 1962. 32p. [Contract AF 33(616)-7665].

Results of an experimental program to determine the solubility and diffusion rate of nitrogen, hydrogen, and oxygen in beryllium are reported. The solubility of nitrogen in beryllium at 1000° C is estimated to be about 60 ppm; this value appears to be temperature independent. The results of nitrogen diffusion experiments are considered tentative. The solubility of hydrogen in beryllium is believed to be very small. Measurement of the growth characteristics of hydrogen bubbles formed in beryllium by proton bombardment indicate a value for the diffusion coefficient of hydrogen in beryllium of 9×10^{-10} cm^2/sec at 850° C. Due to limitations of chemical analysis, no new data concerning the beryllium-oxygen system were obtained.

135. Pointu, P., P. Azou, and P. Bastien
Contribution to the study of the mechanism for the production of rolling and extrusion textures in beryllium. REVUE DE METALLURGIE. MEMOIRES SCIENTIFIQUES v.59, no.5, p.321–342. May 1962. (In French)

Single crystal and polycrystalline beryllium rolled and extruded forms are studied to determine the effect of plastic deformation on preferred orientation; prismatic sliding systems; stability of pole of basal plane; presence of twin crystals and intergranular deformation and flow stability and direction.

136. Salmen, W. J. and L. P. Gobble
TENSILE PROPERTIES OF BERYLLIUM FROM ROOM TEMPERATURE TO 1600° F. American Society for Testing Materials. Preprint No. 67. 1962. 12p.

Determination of the modulus of elasticity, yield and ultimate strengths and elongation by testing QMV Be blocks at room temperature to 1600° F using a strain rate of 0.005 in. per in. per min; analysis of the tensile properties and stress strain curves as a function of temperature.

137. Smith, M. J., R. J. Knight, and C. W. Spencer
Properties of Be_2Te_3-Sb_2Te_3 alloys. JOURNAL OF APPLIED PHYSICS v.33, no.7, p.2186–2190, Jul 1962.

Alloys are prepared by mixing above the melting points, cooling and quenching. Measurements are made of the phase diagram, lattice parameters, electrical resistivity and thermal energy gap as a function of temperature and composition.

138. Soffa, L. L.
Nondestructive testing of hot pressed beryllium for inertial instrument applications. NONDESTRUCTIVE TESTING v.20, p.242–244, Jul–Aug 1962.

Nondestructive testing methods for hot pressed Be are discussed. X-ray examination was found to be a very effective method for screening Be nondestructively for internal defects. Fluorescent penetrant testing serves as an excellent supplementary method to x-ray examination for testing the surface quality of Be after heat treatment, machining, and other fabrication processes. Electron probe microanalysis is effective in identifying inclusions and impurities. Under certain circumstances it is also nondestructive. X-ray resulted in a better understanding of the physical behavior of the material.

139. Treharne, P. I., and A. Moore
Tensile deformation of beryllium single crystals in various orientation between 25° C and 600° C. JOURNAL OF THE LESS-COMMON METALS v.4, no.3, p.275–285, Jun 1962.

Single crystals of predetermined orientation have been grown from the melt by a floating zone technique using "seeds" to nucleate the required orientation. The crystals have been prepared from vacuum cast and extruded electrolytic flake of the highest commercial purity available. The level of purity obtained is 99.83% and the critical resolved shear stress for basal (0001) slip has been measured in tension from 25° C to 600° C, in crystals which have deformed only by basal (0001) slip. The critical resolved shear stress for (0001) slip remains constant at 750 psi in the temperature range 300° to 600° C and increases only X 5 in the range 300° to -196° C. This small rise in critical resolved shear stress contrasts markedly with that found for $(10\bar{1}0)$ slip, which increases by X 9 in the same temperature range from ~ 1,500 to 13,000 psi. By comparison with similar work on metal 99.0% purity, it is concluded that increasing purity reduces the critical resolved shear stress for both (0001) and $(10\bar{1}0)$ slip throughout the temperature range 25° to 600° C by ~ X 2. It is suggested that the independence of critical resolved shear stress for (0001) and $(10\bar{1}0)$ slip with temperature in the range 300° to 600° C implies that the beryllium lattice is hardened by increasing its solute concentration.

140. Hodge, W.

Beryllium. DMIC REVIEW OF RECENT DEVELOPMENTS. 17 Aug 1962. 4p.

Review of literature pertaining to the annealing, extrusion, fabrication, and strength and chemical property determinations of Be, Be sheet and Be foil. Included is a report on the toxicity of Be and on the application of Be as a diffusion-bonding agent for joining iron, nickel and cobalt-base alloys.

AUTHOR INDEX